INDEXED

Volume 21 October, 1935 *Number 10*

Lubrication

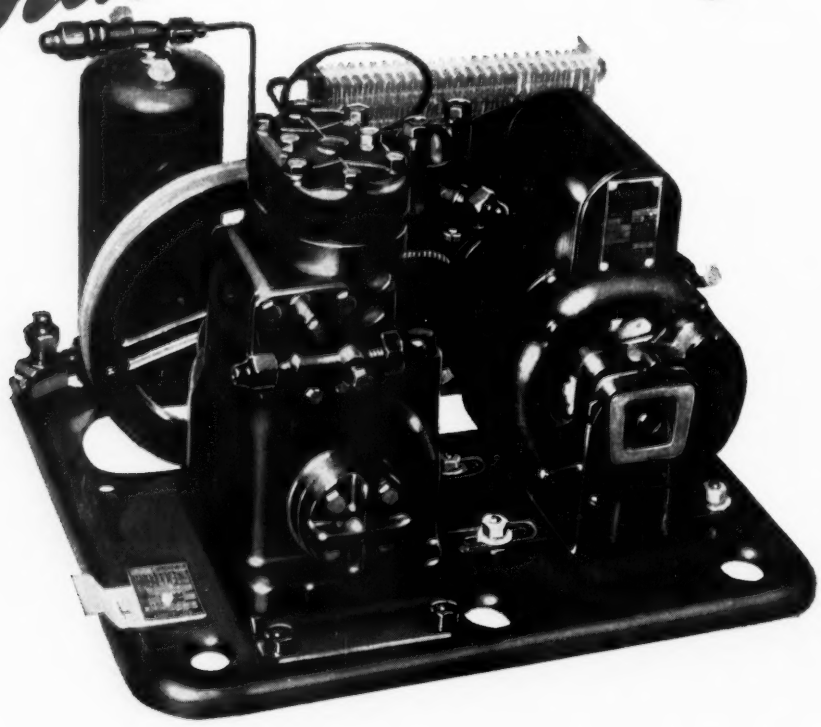
A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

Electric Refrigeration

PUBLISHED BY
THE TEXAS COMPANY
TEXACO PETROLEUM PRODUCTS

What lubricant?



It's a vital question for every manufacturer of domestic refrigeration equipment. New refrigerants and modernized design have introduced entirely new lubricating problems. In working out these problems, Texaco research has been notably successful.

Texaco engineers and chemists, in the Texaco research laboratories and refineries, have for years given their whole-hearted cooperation to manufacturers in this field. New refining methods have been developed and new lubricants provided to help maintain the high efficiency of modern refrigeration equipment.

Texaco offers a complete series of specialized compressor lubricants to meet every condition. These oils are remarkable for their resistance to sludging, oxidation, and the reactive changes due to contact with present day refrigerants. Their stability, excellent lubricating qualities and low pour points assure continued trouble-free operation. They are tested in the laboratory, proved in service.

Texaco is doing constructive work for the industry, in helping bring about better lubrication — making available oils best suited to each individual unit. Write The Texas Company on any question of lubrication.

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LUBRICATION

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Electric Refrigeration

THE development of the machinery essential to a new industry or to any branch of an already established industry has always presented a variety of unique problems. Where industrial production has been involved these have usually become a function of design, with the result that ways and means of handling the product and synchronizing operations have seemed to be most important to the designing engineer. Hence, he assembled the various necessary mechanisms to bring about the desired motions and then investigated their lubrication requirements in accordance with the operating conditions and product to be handled. Normally, he was not concerned with chemical solutions or the possibility of chemical reactions.

Electric refrigeration, however, presented this additional problem. So in the development of the refrigerating system and the study of a wider variety of refrigerants than had been employed in the wholesale manufacture of ice, the designing engineer wisely took the chemist into his counsel. It was but natural for the latter to realize the importance of research, where complicated chemicals were involved and when they must come in more or less intimate contact with lubricating oil under fairly high temperatures and pressure. Furthermore, certain of the refrigerants so adaptable to unit refrigeration work had been proved to be highly selective in their solvent effect upon certain types of petroleum hydrocarbons. So the study of lubrication of the electric refrigerator, and the selection of suitable lubricating oils became one of the outstanding problems of the industry and demanded the most exhaustive research.

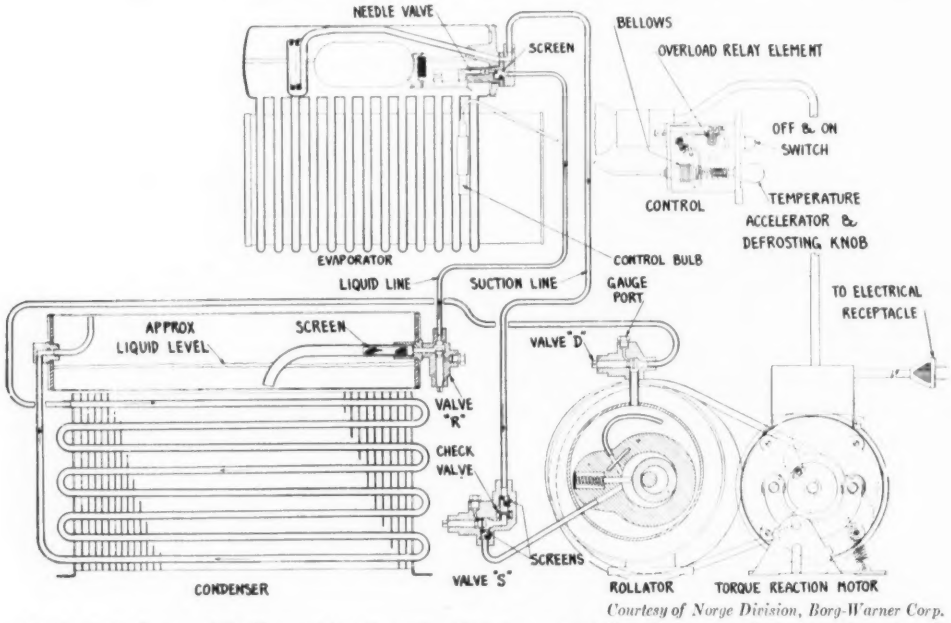
Early in this research program, leading authorities were unanimous in their opinion that solvent refining should be a function of the manufacturer of the oil, not of the machine, for the residual products of this reaction were of a gummy nature and prone to accumulate on valves, in cylinder heads and on discharge lines, where they would interfere seriously with compressor performance and even in extreme cases cause cessation of operation. As a result the petroleum industry, in turn, had to take a thorough interest in this new development.

THE PRINCIPLES OF REFRIGERATION

"How it works" is often a point of interest to any owner of an electric refrigerator. Even the technician or practical engineer must sometimes stop to think out the refrigerating cycle. So a word as to what goes on when one plugs the connection into the electric socket will be in order. Obviously, an electric motor is essential to run the unit, and electric current runs the motor to bring about rotary motion. Through a suitable connection to the compressor this rotary action is transformed into reciprocating motion in the cylinder type of unit or it rotates the rolling element in the rotary machine. The compressor is one of the most important parts of a refrigerating machine; its function is to reclaim and compress the chemical vapor or gas—a procedure which is necessary continuously to complete the refrigerating cycle.

This process of refrigeration involves the

transfer of heat from any given article or space which is to be cooled. In the conventional ice box, ice serves as the cooling medium. Being chemical in the liquid state; by allowing it to evaporate, a phenomenon which is controlled by passing it through an expansion or regulat-

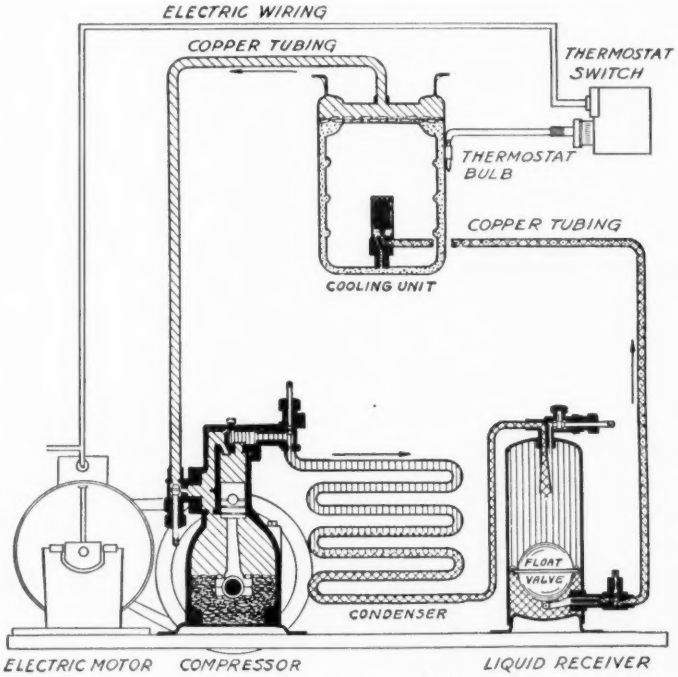


Courtesy of Norge Division, Borg-Warner Corp.

Fig. 1—Cycle diagram of the Norge refrigerating unit. Oil in the system follows the same path as the refrigerant, only more slowly. Arrows indicate direction of flow.

of much lower temperature than the contents or interior of the box, it tends to absorb heat from the latter. As this occurs, the temperature of the box is lowered, but at the same time the temperature at the surface of the ice is raised above the freezing point, hence melting takes place. The extent to which a cake of ice can properly cool an ice box will of course depend upon the total area of its exposed surfaces. Where this area can be kept constant, uniform cooling will be accomplished. Otherwise, the temperature of the box will rise gradually due to outside influences, as the cake of ice becomes smaller.

The electric refrigerator replaces ice through the cooling effect of some liquid chemical of comparatively low boiling point. By proper circulation of this chemical through a suitable heat exchanger or cooling unit, a constant and uniform rate of heat transfer to this element from the space to be cooled is brought about.



Courtesy of Kelvinator Corporation

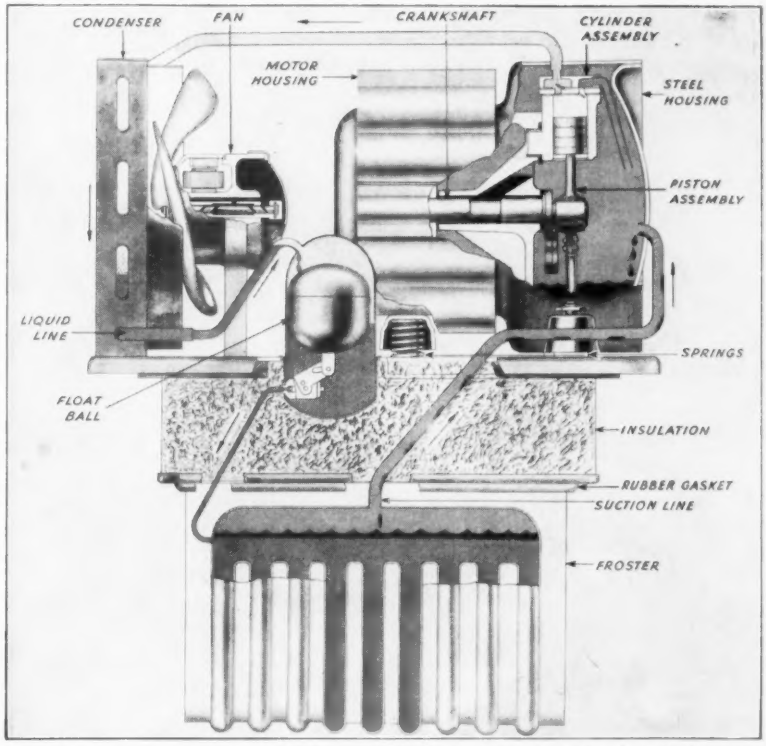
Fig. 2—The Kelvinator cycle showing relative location of electric motor and compressor with respect to other parts. The normal oil level is shown in the base of the compressor.

In the circulation of any such chemical, there must be provision for handling, both in liquid and gaseous state. The actual work of refrigeration is done with the ing valve. Evaporation, which is a result of boiling of the refrigerant, is effected by the

drop in pressure which occurs as the refrigerant passes through the expansion valve.

Physics refers to the latent heat of the refrigerating medium in discussing refrigeration and heat transfer. In this connection it means the amount of heat necessary to change a product from liquid to gaseous state at its boiling point. So, according to the rate at which liquid refrigerant is passed through the expansion valve, converted into gas and passed into the evaporator, heat is taken up and the temperature of the space surrounding the evaporator is lowered. This space is the interior of the refrigerator cabinet. To complete the cycle this gaseous refrigerant must then be again converted to liquid form, a procedure which necessitates a compressor and condensing unit.

The equipment essential to a complete electric refrigeration installation therefore requires an electric motor, a compressor, condenser, the refrigerant receiver, an expansion valve (an oil trap or separator in some types of design) and the cooler or evaporator.



Courtesy of Westinghouse Electric & Manufacturing Company

Fig. 3—Cycle of operation of the Westinghouse stream-line refrigerator. The oil in this system is shown in heavy black. Note path followed by oil along with low pressure refrigerant vapor from the froster to the base of the compressor. Note also the fan motor which is lubricated from a permanent oil supply carried in the motor housing.

Operation of the Compressor

From the viewpoint of lubrication, the compressor is the most important part of the system. For the information of the layman, this machine functions somewhat as a pump, being designed to compress the gas from a comparatively low pressure to a higher pressure.

Reciprocating Units

The reciprocating type of compressor resembles in principle the automobile engine in design with the exception of the number of cylinders. Normally, the electric refrigeration compressor will have only one or two cylinders. In these cylinders are fitted the pistons with suitable connecting rods, wrist pins and crank connections.

The compressor crankshaft may be directly connected to the driving motor through a yoke connection or some other type of fixed coupling, or a belt connection may be used.

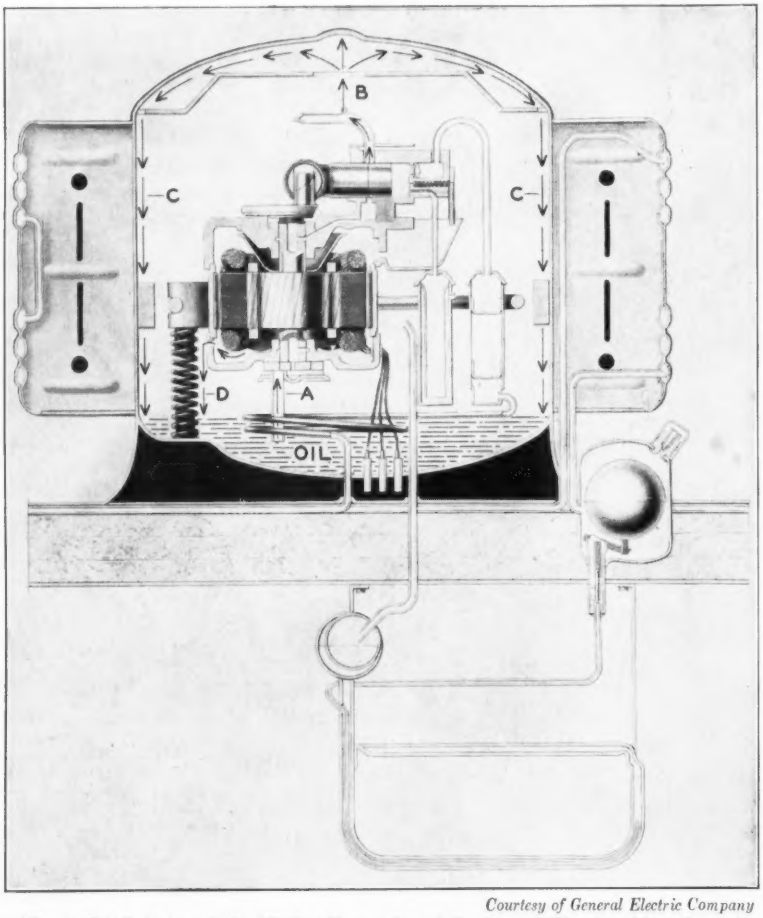
There is a marked difference in piston and cylinder design of the household type refrigerating compressor as compared with practically any other type of reciprocating machine, in that piston rings are rarely used. Instead, the designers plan for very close clearances between pistons and cylinder walls, and depend upon the lubricating film to maintain the necessary seal.

Another marked difference pertinent to this machine is the manner in which the gas to be compressed is drawn into the cylinders. In contrast with the conventional mode of handling the gas in any other type of compressor or engine, i.e., taking the charge from the topside as is customary in the automobile engine or air compressor, the electric refrigerating compressor has provision for drawing in the low pressure gaseous refrigerant through the crankcase, using valve mechanisms adjacent to or a part of the piston.

The Rotary Type

The rotary positive displacement type compressor brings about compression through the rotation of an eccentrically driven roller which moves in a gyratory manner in a closed cylinder. The inlet and discharge passages are separated by a suitable blade which is held in contact with the roller surface by springs or oil

pressure. Oil also serves to maintain the necessary seal between the surfaces of the roller and housing. Submersion of all the moving parts in oil under pressure therefore protects them adequately against wear and enables manufacture to very close clearances.



Courtesy of General Electric Company

Fig. 4—Detailed view of the Monitor Top section of the General Electric refrigerating unit. Lubrication of this element is of distinct interest. Oil is carried in the base of the machine. Circulation of oil from points "A" and "B" is as follows: A small rotary oil pump located on the end of the shaft carries oil up through this hollow shaft and then through a by-pass to the compressor. Oil is also carried to the crank through a hole running from the main shaft to the side of the crankpin. When the oil leaves the compressor, part of it is discharged vertically at a point marked "B" flowing upward and outward as indicated by arrows and following along the walls of the housing to return to the base. The remainder of the oil from the compressor flows out of another opening over the end of this part of the machine. This oil serves to cool the compressor and particularly the valves. The overflow spills into a cup which carries it to the motor compartment to flood and cool the windings. Small holes in the stator allow the oil to drain to the lower winding compartment, from which it spills through an overflow hole and returns to the sump as indicated at "D."

Function of the Condenser

Irrespective of the type of compressor, the condenser performs the same function in a refrigerating system in that it brings the gaseous compressed refrigerant to a liquid state. This requires cooling of the condenser surfaces, which is accomplished by natural circulation of room air in the electric household unit, or by cooling water in some types of commercial installations.

The condenser is a form of heat exchanger just as is the evaporator. In the former, however, heat is taken away from the refrigerant, whereas in the evaporator this action is reversed; the refrigerant serving to take up heat.

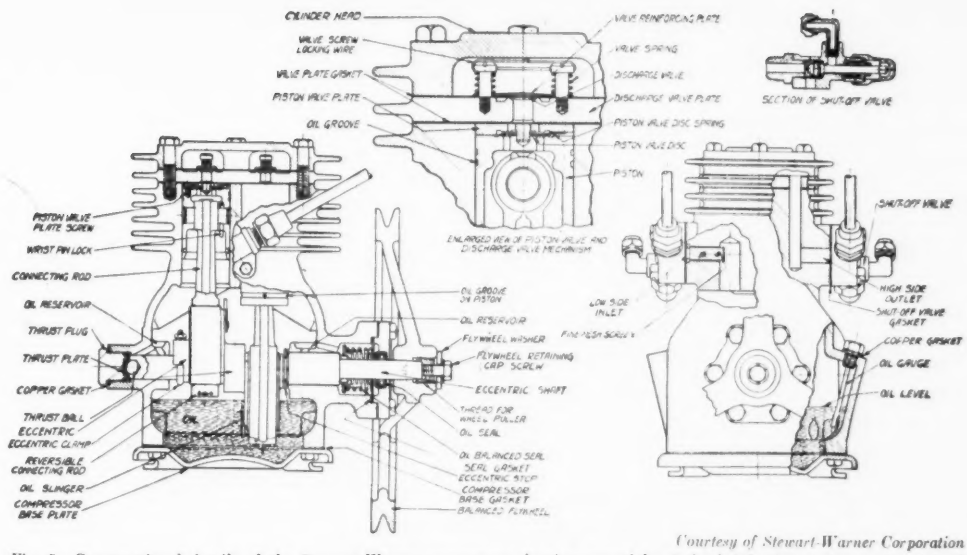
After passage through the condenser, the refrigerant is therefore ready to do work and perform its intended function in absorbing heat from the air in the cabinet and from the water in the ice trays to make ice cubes.

SULFUR DIOXIDE

Sulfur Dioxide has long been one of the most popular refrigerants for small unit service, due to its ability to function at comparatively low pressures, its economy of manufacture and low cost to builders of refrigerating machines. In liquid form, it is colorless, but in either liquid or gaseous state it has a strong, pungent odor and is highly toxic. On the other hand, this odor is regarded as an advantage inasmuch as leaks can be readily detected before concentration of the vapor in the air becomes dangerous.

In the handling of sulfur dioxide in refrigeration service, the utmost care must be observed in drying the unit and using a dehydrated lubricating oil, for this chemical is readily soluble in water, in which solution it becomes strongly acidic, and highly corrosive with respect to certain of the metals used in the system. Sulfur Dioxide, however, is not completely miscible with petroleum lubricating oils in the liquid phase at refrigerating temperatures, hence there is but little possibility of much change in the original viscosity of an oil other than the normal change due to temperature fluctuations. In fact, Sulfur Dioxide is even claimed by some authorities to possess a certain amount of lubricating value itself, which is a distinct advantage in an entirely dehydrated system.

On the other hand, according to Philipp & Tiffany, in their paper entitled "Thermo-



Courtesy of Stewart-Warner Corporation

Fig. 5—Constructional details of the Stewart-Warner compressor showing essentials of the lubricating system. Special oil slinger paddles attached to the eccentric splash oil onto the cylinder walls and into the reservoirs which lead to the bearings. Oil grooves cut in the sides of the pistons in turn assure of a source of lubricant for the cylinder walls.

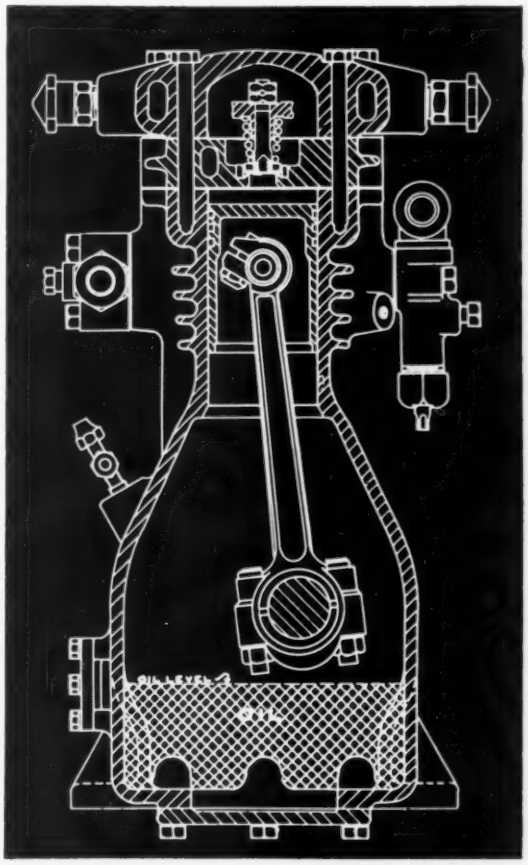
dynamics of Sulfur Dioxide Oil Systems,*"

"The presence of lubricating oils in contact with liquid sulfur dioxide† has been shown to change some of its physical properties, such as the evaporation temperatures, vapor pressure, surface tension, etc. Both gaseous and liquid sulfur dioxide react with some lubricants with the formation of lubricant sludges or carbonaceous solids. The proper selection of a lubricant becomes, therefore, a very important consideration."

"When oil is exposed to sulfur dioxide vapor, some of the vapor dissolves in the oil. The quantity dissolving depends on the temperature of the system and the pressure of the vapor. If the pressure is less than the saturation pressure for the vapor at the temperature of the system, only one liquid phase is obtained. The lower the temperature of the oil the more vapor it can dissolve at a given pressure."

There is an advantage to this solubility factor, however, in that it can be made use of to get oil which has been pumped into the condenser and receiver into the evaporator. The same authors state that:

"This is done primarily by dissolving the lubricant in the liquid refrigerant in the receiver. It is important, therefore, to have a lubricant which is quite soluble in liquid sulfur dioxide at room temperatures and as nearly insoluble as possible at low evaporator temperatures. If the solubility of the lubricant in the liquid refrigerant at receiver



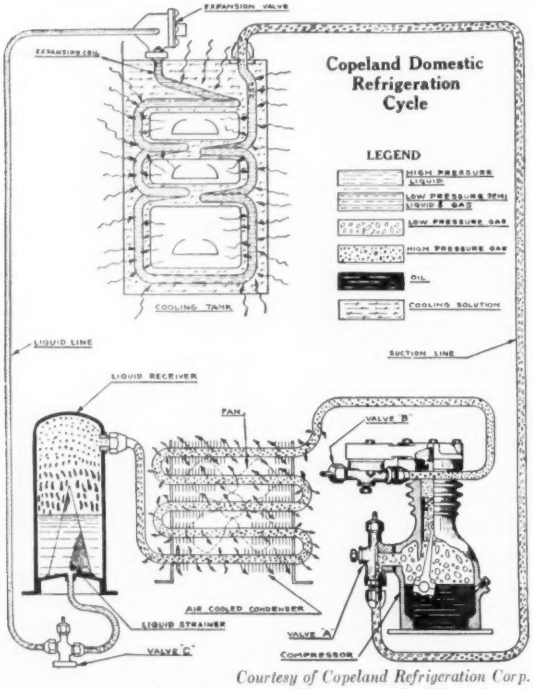
Courtesy of Universal Cooler Corporation

Fig. 6—Sectional view of a Universal Cooler condensing unit, showing relative location of essential parts and the oil level in the base of the compressor. All refrigerant gases and vapor are excluded from the crankcase which holds only the lubricating oil and the oil mist from crank splash.

* Thermodynamics of Sulfur Dioxide Oil Systems, PHILIPP, L. A.: TIFFANY, B. E., Research Department, Kelvinator Corp., Detroit, Michigan. "Refrigerating Engineering" May, 1934—p. 248.

† Ebullition of Refrigerants, PHILIPP & TIFFANY, "Refrigerating Engineering," March, 1933—p. 140.

temperatures is low or if the compressor pumps a large quantity of lubricant, there will be an accumulation of lubricant in the liquid receiver whenever a low side float valve, expansion valve or thermostatic expansion valve is used. Obviously it becomes desirable, therefore, to obtain a lubricant with a high temperature coefficient of solubility in liquid sulfur dioxide."



Courtesy of Copeland Refrigeration Corp.

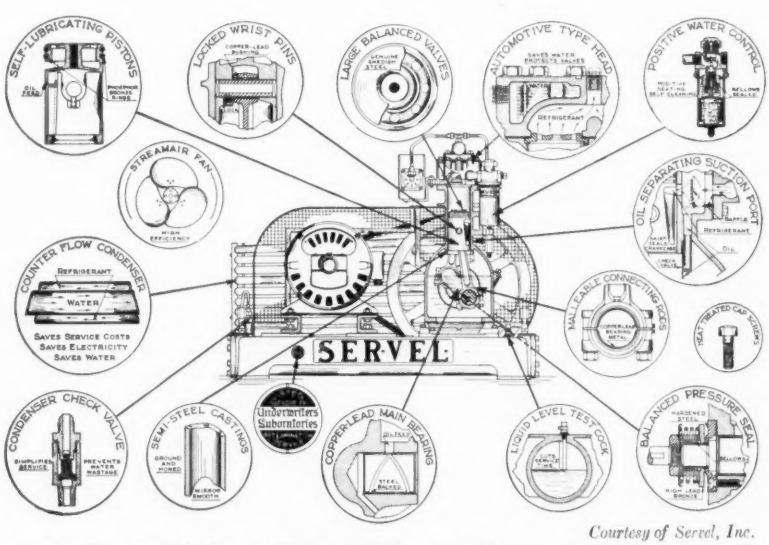
Fig. 7—The Copeland domestic refrigeration cycle. Note legend which indicates high and low pressure gas, the lubricating oil, etc. The compressor in this installation is lubricated by oil splash.

It has also been determined that:

". . . it is possible to utilize a lubricant which is quite insoluble in liquid sulfur dioxide at all temperatures, providing a fixed restriction or high side float feeding device is utilized for metering the liquid refrigerant to the evaporator. Whenever a low side float, expansion valve or thermostatic expansion valve is employed, an oil which is soluble in liquid sulfur dioxide at room temperature and quite insoluble at the evaporator temperature is desirable."

Effect of Impurities:

"Water produces the most harmful reactions in a sulfur dioxide refrigerating system. The quantity of water in the system and the type of system determine in general the extent of the corroding effect in the system. The sulfur dioxide which is commonly used today in refrigerating systems has water contents on the average of about 0.001 per cent by weight. The refrigerating system is usually baked at a temperature of 250 degrees Fahr. to 275 degrees Fahr. for a period of four hours under a vacuum of less than $\frac{1}{4}$ in. mercury absolute pressure. We are quite safe in saying that with these precautions for moisture removal the absolute moisture content in the completed system is extremely low. The quantity of moisture and the place of introduction of this moisture into the system will determine the extent of damage. If the moisture is introduced into the compressor or remains in the compressor so that it emulsifies with the lubricating oil and sets up a local high concentration, the reaction between the sulfur dioxide and the ferrous metals becomes quite rapid and severe. The temperature in the compressor, the emulsifying effect of the lubricant and the possibility of reaching a high localized concentration of water, all are suitable for accelerating the corroding reaction of the sulfur dioxide with the ferrous metals."



Courtesy of Servel, Inc.

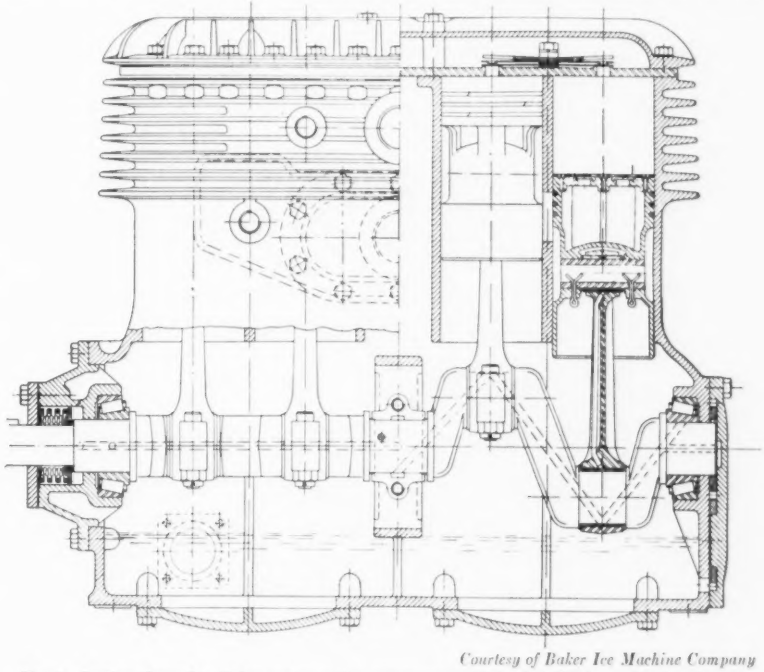
Fig. 8—The Servel electric refrigeration condensing unit with essential parts shown in detail. Inasmuch as all refrigerating machines using methyl chloride, Freon or other similar refrigerants circulate some oil with the refrigerant, provision is made for returning this to the crankcase through special check valves connected to the suction port.

FLUORINATED REFRIGERANTS

The halide derivatives of the aliphatic hydrocarbons contain one or more fluorine atoms. Dichlorodifluoromethane, commer-

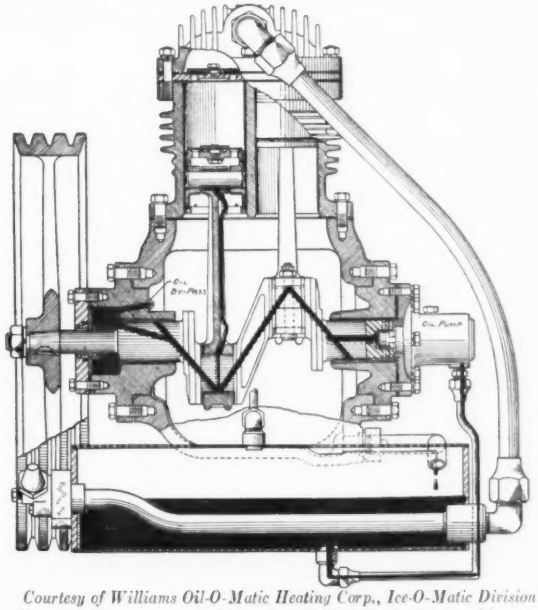
cially known as Freon or F-12, is the best known of these products. They are advantageous for refrigerating systems due to their extremely low toxicity, being even less toxic than carbon dioxide.

Freon is practically non-soluble in water and does not alter the taste of drinking water; furthermore, it has no effect on furs and most foodstuffs. Its mixtures with air are practically odorless and if a system installed in a theatre or other public place should leak, there would be no panic of the audience as they would not even know that they were being exposed to its vapor. They also could not be injured because concentrations as great as twenty per cent may be inhaled for a long period of time without causing any organic disturbance. These products are also non-corrosive to the metals which are used in refrigeration equipment and are non-flammable and non-explosive. Leaks of these refrigerants are easily detected by means of a halide lamp and the Underwriters' Laboratories say concerning dichlorodifluoromethane "The hazards to health resulting from exposure to dichlorodifluoromethane when used as a refrigerant are judged to be remote. Consideration of available data indicates that dichlorodifluoromethane is in a class with the practically non-toxic gases."



Courtesy of Baker Ice Machine Company

Fig. 9—Section through a Baker reciprocating compressor. Note that Timken roller bearings are used as main bearings. All the bearings in this unit are under full force feed lubrication which is maintained by a built-in, positive drive, high pressure, gear type oil pump.



Courtesy of Williams Oil-O-Matic Heating Corp., Ice-O-Matic Division

Fig. 10—The compressor body of a Williams Ice-O-Matic refrigerating unit, showing the pressure lubrication system. The oil pump is of the rotary gear type and is driven from the crankshaft. Note that the oil supply is removed from the crankcase to an auxiliary oil tank, thereby giving a "dry" crankcase. Oil in the system is indicated by heavy black.

Hydrocarbon Compounds

The aliphatic hydrocarbons, such as ethane, propane, butane, and iso-butane, have also been used as refrigerants. At the present time they are not being considered for use in refrigerating equipment due to their inflammability and explosive nature. In consequence, they should not be used where leakage would mean exposure to open flame.

Oxidation and Breakdown

The possibility of oxidation being induced by leakage of air into a freon charged compressor is virtually eliminated, inasmuch as chemicals of this nature, functioning at a low positive back pressure, prevent entry of air instead of tending to leak out themselves. Authorities believe that outward leaks are better than inward leaks of air, assuming, of course, that the refrigerant is non-toxic, non-irritating, non-inflammable, non-explosive and not injurious to food, and therefore not capable of causing panic or fire hazard. It is also felt that this insurance against inward leakage of air will reduce the possibility of sludging or oxidation of compressor oils.

Lubrication

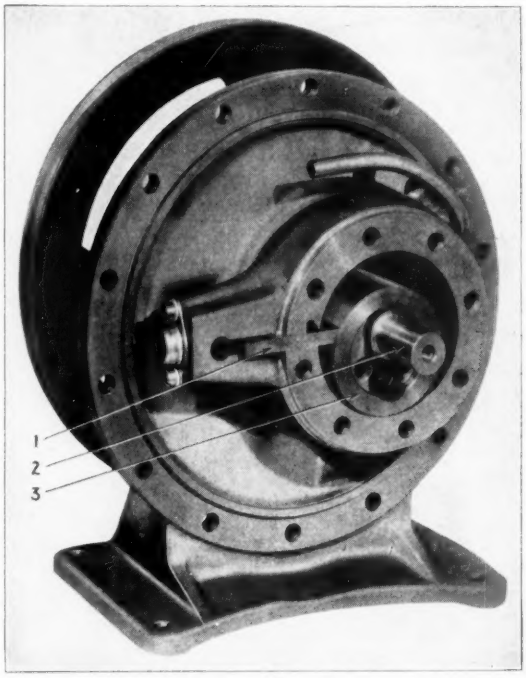
In regard to lubrication, the remarks of R. J. Thompson, of the Kinetic Chemicals, Inc., in Technical Paper No. 11, are distinctly interesting.

"The lubrication of a Freon charged compressor is similar to that of a compressor using a refrigerant that is completely miscible with mineral lubricating oil, such as methyl chloride. Since Freon and mineral oil are completely miscible, an oil of higher viscosity is required than when using a refrigerant that is not miscible with the lubricating oil."

"The proper selection of a lubricating oil can only be made after having obtained a clear understanding of the physical conditions under which the compressor and system is to be operated. Factors which must be taken into account are, bearing loads, rubbing speeds, clearance, type compressor (enclosed or open frame), type compressor (air or water-cooled), temperature of evaporator, type evaporator (flooded or dry expansion), etc."

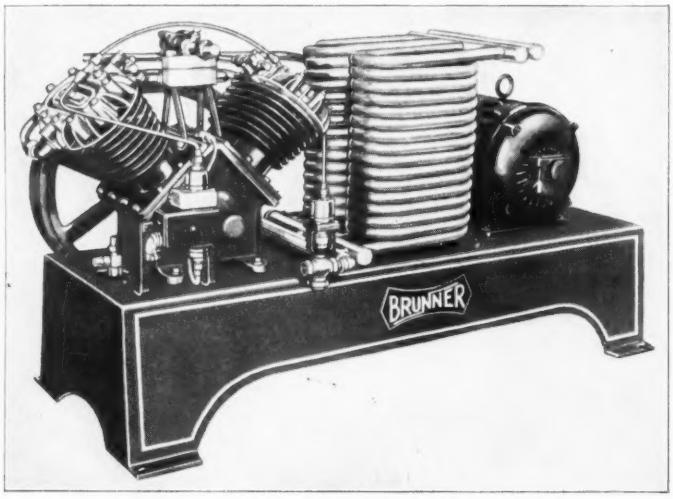
"With this group of factors which are quite variable, an almost endless number of combinations can be produced which will require lubricating oils of various characteristics."

"It must be recognized that a small capacity, low horsepower, slow speed, enclosed type, air-cooled compressor operating a flooded evaporator at temperatures well below the freezing point of water, will function efficiently with a very light, low viscosity and low pour point oil. While in contrast, a large capacity, high horsepower, high speed, water-cooled compressor using trunk type pistons or an open frame, operating a flooded evaporator well above the freezing point will require a higher viscosity and higher pour point oil. Between these two extremes there will exist various combinations of conditions with the result that it is not possible or wise to recommend an oil of any particular viscosity, flash point, fire point, pour point, etc., to meet all of the various operating conditions."



Courtesy of Norge Division, Borg-Warner Corp.

Fig. 12—The Norge "Rollator" principle. Note the three moving parts, i.e., blade, roller and cylinder. These parts operate continually in a bath of oil.



Courtesy of Brunner Manufacturing Company

Fig. 11—Showing the Brunner Model W-500 unit, adaptable either for electric refrigeration or air conditioning service. When used for electric refrigeration, this unit normally operates on methyl chloride. Lubrication of all parts of the compressor is accomplished by splash.

"For small domestic refrigerating systems of the enclosed type, an oil of 150 (for flooded systems) to 300 (for expansion systems) viscosity, flash point 350 to 425 degrees Fahr., fire point 390 to 475 degrees Fahr., and a pour point of —10 to — 30 degrees Fahr., may be used with complete satisfaction considering the operating conditions."

"The lubricating oil for use with Freon charged compressors should be a straight run and properly refined mineral oil and obviously must not contain water, sediment, acid, soap, resin or any substance not derived from petroleum and must not form wax or gum in the presence of Freon. Also, the oil must not corrode any metal used in refrigeration construction."

"Mineral lubricating oils must be thoroughly dehydrated, not because of any chemical reaction but for the reason that any moisture in the oil will freeze out and thus restrict the flow of refrigerant through the regulating valve."

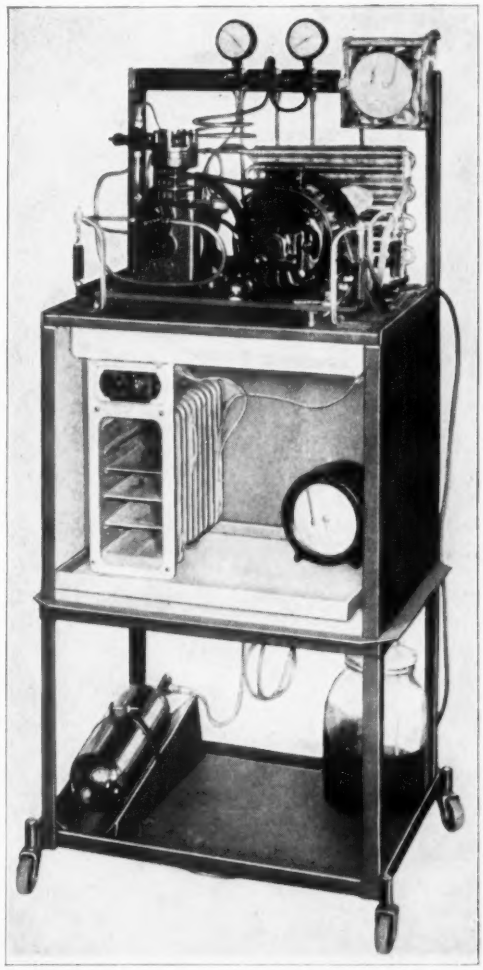
"The question may arise as to the manner in which the oil contained in the flooded evaporator will return to the compressor crankcase, and in the following will be given an explanation as to this question. As the evaporator absorbs heat and the gas bubbles rise to the surface of the Freon-oil solution, the oil film of the bubble is ruptured and these finely divided oil particles form a mist in the Freon vapor and are swept along by the gas stream formed by the ebullition of the refrigerant. These oil particles or oil fog will blanket the Freon-oil solution to a height or thickness in the evaporator which may be predetermined by experiment and will be dependent upon evaporator temperature, capacity, design, location of oil vapor return tube in relation to Freon-oil solution and also the characteristics of the oil itself."

"The Freon vapor which is being returned to the compressor will carry this oil fog through the suction line and return the lubricating oil to the compressor crankcase (closed type), cylinders (trunk or open frame type compressor) or oil interceptor, as drops of oil."

"Oil logging of the flooded evaporator will occur, should the suction or oil fog return tube be placed too high above the surface of the boiling liquid refrigerant, which will permit the oil fog to settle back into the Freon-oil solution. Frosting or sweating of the return line will occur, should the suction tube be placed too close to the surface of the boiling refrigerant where particles of liquid Freon may be splashed or drawn into and vaporized in the return line to the compressor. There will be no oil logging of evaporators of an expansion system due to the high velocity of refrigerant vapor or gas in the return line pushing along any oil particles."

"Freon absorbs small quantities of mineral oil depending on the oil characteristics (pour point and viscosity), the temperature of the oil in the crankcase and the operating back pressure in the compressor crankcase, but unlike other refrigerants (other than hydrocarbon refrigerants) does not deposit the lubricating oil in the low side of the system and cause oil logging. More Freon will be absorbed by the oil at higher pressures and at lower temperatures, or vice versa."

"During the off-cycle of the compressor, the oil temperature in the crankcase is lowered and the back pressure is increased which will permit the Freon vapors to become absorbed by and condensed in the mineral oil. At the time the compressor starts operation, the back pressure in the low side crankcase is suddenly reduced with the result that the Freon in solution with the crankcase oil will boil out causing the lubricating oil to foam. Should the system be overcharged with oil, this foaming oil will be scrubbed through the intake and discharge valves and the excess amount of oil in the crankcase will soon pass into the receiver and into the low side of the system. When the compressor is charged with the proper amount of oil there will not be excessive splashing of oil by the eccentrics or crankshaft and the foaming of the oil will not cause faulty operation of the compressor or evaporator."



Courtesy of Crosley Radio Corporation

Fig. 13—A Crosley refrigerator test stand, showing relative location of the condensing unit and instruments essential to experimental work.

"Small tonnage compressors using the splash system of lubrication which return the refrigerant vapors and oil direct to the compressor crankcase, may have oil level regulating devices or controls. Small capacity

units designed for household installation should not be overcharged with oil and since this oil charge may be very easily controlled, there is no occasion for using oil-level regulating devices."

Courtesy of General Electric Company

Fig. 14—The oil pump for the General Electric type CM condensing unit. This device is an oscillating cylinder type of reciprocating pump operating from an eccentric on the end of the crankshaft.

METHYL CHLORIDE

This chemical as manufactured for refrigeration purposes from methyl alcohol and hydrochloric acid is a gas under atmospheric conditions although it is marketed as a liquid under considerable pressure. It is colorless under both conditions, neutral to litmus, contains practically no water and has but a slight odor akin to ether. Research as to its stability has indicated that in the absence of moisture, it is non-corrosive to metals and non-injurious to lubricating oils, although it does mix with the latter to bring about some reduction in viscosity.

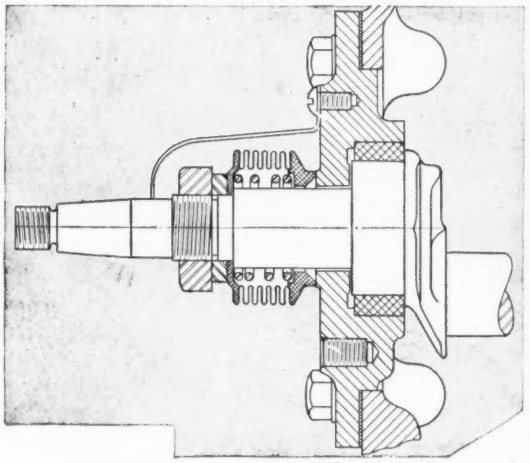
Relative to lubrication and the properties essential in a lubricant for use with methyl chloride, the R. and H. Chemicals Department Sales Division of E. I. duPont de Nemours & Company, Inc., state:

"In types of equipment containing large charges of methyl chloride, where leakage of the refrigerant may result in exposure of persons to higher concentrations of the gas and thus present a hazard, it is customary to use methyl chloride containing a warning agent, for example, 1% of Acrolein which acts as an eye, nose and throat irritant. Irritants are not present in the majority of methyl chloride installations as these consist of small unit systems where leakage of the entire refrigerant charged would result in only low and relatively harmless concentrations of the gas."

"Most of the special problems presented by the higher pressure refrigerants of the hydrocarbon and the halo-hydrocarbon groups, such as the problems of oil foaming and oil return in methyl chloride and Freon machines are identical, although less methyl chloride dissolves in the lubricating oil due both to the lower absolute solubility of the methyl chloride in the oil and to the lower operating pressures of the methyl chloride machines."

"The tendency for methyl chloride to dilute the lubricant points toward the use of higher viscosity oils. This same solubility factor makes it generally unnecessary to use very low pour test oils as solution of methyl chloride in an oil lowers the pour point."

"In the early development of methyl chloride



Courtesy of Universal Cooler Corporation

Fig. 15—The shaft seal of the Universal Cooler condensing unit. Sealing the crankshaft against oil, refrigerant and air leakage is one of the major problems in condensing unit design. It is important to maintain tight contact with minimum friction and uniform bearing tension.

equipment, the deposition of copper on steel bearing surfaces was sometimes noted — especially in the case of equipment doing heavy duty such as low temperature ice-cream jobs. Although an exact analysis of the causes of this trouble has not been made, it has been satis-

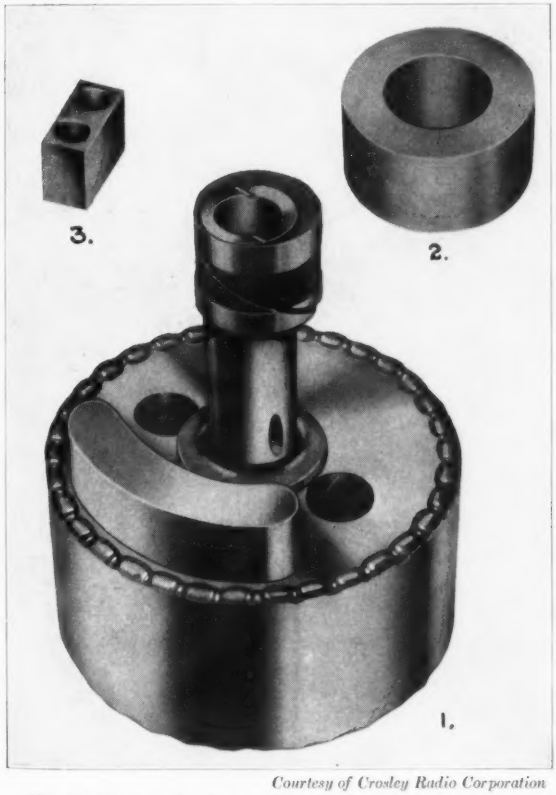
factorily eliminated by resorting to the use of oils low in sulfur content, free from saponifiable matter, free from acidic materials and showing a high resistance to oxidation and, in addition, keeping the refrigeration system free from moisture."

Ethyl Chloride

Ethyl chloride has at various times been considered also for electric refrigeration purposes. It has never become a serious competitor of any of the other refrigerants, however, due to its comparatively high boiling point. Physically, it is much similar to methyl chloride as to toxicity, stability and flammability. Like methyl chloride, it also has no deleterious effect upon petroleum lubricating oils other than to cause a certain reduction in viscosity. It is manufactured from ethyl alcohol and hydrochloric acid.

CARRENE

This is another of the chlorinated hydro-



Courtesy of Crosley Radio Corporation

Fig. 16—Showing the three working elements of the Crosley rotary compressor. "1" indicates the eccentric or rotor shaft, "2" is the impeller and "3" is the blade which separates the high pressure from the low pressure side within the unit.

carbon refrigerants which has come into considerable favor for use especially in the centrifugal or rotary type of compressor. Carrene, known to the chemist as dichloromethane, has lent itself admirably to this type of design especially where operation is carried out under a vacuum on both the "high" and "low" sides and where there is but little likelihood of the refrigerant leaking into the atmosphere and creating a hazard. Like other chlorinated hydrocarbons such as methyl chloride, Carrene is also virtually inert to the metals used in refrigeration equipment; on the other hand it mixes readily with petroleum lubricating oils to reduce their viscosity. In consequence, this tendency must be borne in mind when deciding on the original viscosity of any oil for service with this chemical.

SYSTEMS OF LUBRICATION

There has been a lot of consideration given to methods of lubrication in the development of the unit refrigerating compressor. With automotive experience as a background and the comparatively successful results obtainable from splash lubrication, as it was used when the electric refrigeration industry first came into prominence, it was logical that this means of lubrication should be favored. It has proved its dependability and economy and still is preferred by many builders. More recently, however, there has been extensive research into the adaptability of pressure, either alone or together with splash, the purpose being to obtain positive circulation of oil throughout the compressor and to eliminate foaming as far as possible. Obviously, in a splash - lubricated reciprocating compressor, foaming will always be present. The extent to which it may be objectionable will depend upon the oil level and the location of the suction valves. Inasmuch as the unit type of compressor takes its suction through the crankcase, if the foam level rises to a sufficient degree foam may be carried over to the high side with the refrigerant to cause serious retardation of heat transfer. Ultimately, if allowed to continue, cleaning of the system may be necessary.

The automotive type of gear pump for oil distribution proved equally adaptable to the refrigerating compressor. The typical gear pump as designed for positive delivery of oil is a comparatively simple device consisting of a pair of gears mounted in a suitable housing. The normal location of such a pump is in the base of the crankcase of the compressor. Some authorities prefer to place this pump at the lowest part of the case. Others are of the opinion that the pump should be set just above a depression or catch basin in the case to provide means for trapping foreign matter and preventing it being circulated through the lubricating system.

Irrespective of the location of the pump, however, suction is automatically maintained

by gravity since the pump is below the normal oil level. The discharged oil, under pressure, according to the speed of rotation of the gears and their relative tooth dimensions, is led from the discharge side of the pump to the connecting rod bearings and other elements by drilled passages and suitable piping connections. As oil passes out from the bearing clearance spaces or drips from the cylinder walls or other parts of the interior housing, it returns to the case or oil sump by gravity for recirculation.

The Rotary Pump

The principles of rotary motion are involved in the floating blade type of rotary oil pump. Two blades free to move in a slotted rotor serve as the pumping media. In the General Electric design, this rotor is fixed to the lower end of the verticle motor shaft. The oil is carried in the base of the unit, being drawn up and pumped through a passage drilled in the motor shaft, and thence through other passages to the yoke arrangement and lower shaft bearings. The majority of the oil, however, goes to the self-aligning top bearing and to the cylinder wall. On leaving these elements, part of this oil returns to the base, the remainder flowing through the stator of the motor to cool the windings.

Oscillating Cylinder Reciprocating Design

Most recent studies in connection with commercial refrigerating units, have been directed towards the adaptability of the oscillating cylinder type of reciprocating pump. This is of single cylinder design, operated from an eccentric on the end of the crankshaft. The entire assembly is located so as to be readily accessible for inspection without removal of other parts.

This pump is designed to supply oil under pressure directly to the two main bearings. From here, oil is passed through holes in the crankshaft to the connecting rod bearings, center bearing and shaft seal. Through tubes, a part of this oil is also pumped to the piston pin bearings. The cylinder walls, however, in any machine equipped with this type of pump are splash lubricated.

LUBRICATION PRACTICE

The owner of the electric refrigerating compressor is normally relieved of the responsibility of lubrication; instead, this is taken over by the builders. In other words, all machines as they leave the manufacturer's plant are lubricated with an adequate charge of oil, which, barring unforeseen development, is capable of maintaining lubrication for a period of several years or longer, according to the operating conditions. When re-lubrication is necessary, it is customary for this to become a part of the service procedure. Uniformity in lubrication is thereby assured and the possibility of use of an unsuitable oil by any machine owner is entirely eliminated.

It has been essential for the builders to follow such a procedure due to the properties of the various chemicals used for refrigeration, as already described. Another factor which imposes a comparatively severe requirement upon any oil used for electric refrigeration service is that, in addition to lubricating the compressor and motor bearings, it must also serve as a cooling medium for the stator windings in some types of machines.

Handling of Lubricants

The methods employed in handling lubricating oils for condensing units should always be given careful consideration. It is essential at all times that every precaution be taken to keep the oil virtually free from water, and the system free from air. In the original assembly, drying and lubrication procedure at the manufacturer's plant, the utmost care is observed in this regard. In servicing, especially where re-lubrication is necessary, it is not always practicable to furnish the service engineer with plant facilities. Hence the practice among many builders of bringing units into a headquarters' service plant or even to their main plant for overhaul.

Where field service must be carried out, lubricating oil should preferably be handled in one to five gallon, sealed cans, obtained directly from the refinery. This will assure of the necessary dielectric strength which is an indication of freedom from water; it will also assure that the oil has not been exposed to sunlight, air or foreign non-lubricating impurities, as might occur so readily if repackaging from bulk is practiced by the machine manufacturer.

Purchase of oil in small capacity, sealed containers is, of course, more costly but when balanced against the cost of rehandling of bulk oils by a machine manufacturer, the ultimate costs should show but very little difference.

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